Swelling Potential on Volcanic Soil of Brecia and Tuff in Jatinangor Area, Sumedang, West Java, Indonesian

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Abstract

This research was conducted in Jatinangor Subdistrict, Sumedang District, West Java Province. Based on the geological mapping, the study area is included in the pyroclastic fall breccia unit, the pyroclastic flow breccia unit, and the tuff unit. This research was conducted to find out the swelling potential of soil from weathered volcanic rock based on the swelling index value from undisturbed soil samples and analysis of clay mineral type from XRD analysis. Testing for swelling index value of soil was conducted by free swell index test method with reference to Indian Standard 2720 Part40 (1977) on each undisturbed soil sample, so that the result of swelling index value of soil in each sample will represent the swelling potential at each undisturbed sampling points. Based on the swelling index value, the research area has a swelling index value between 3.45% - 22.88%. These values based on the Indian Standart 2720 Part40 (1977) classification are included into the low to medium swelling potential level. This value is supported by clay mineral type analysis on some soil samples in the research area using XRD method.

Keywords: Jatinangor, XRD (X-Ray Difraction), swelling index, volcanic, clay mineral

INTRODUCTION

Background

Jatinangor area has grown rapidly into educational areas, industrial estates, business areas, government areas, and commercial areas. In this regard, the sector of infrastructure development is increasing rapidly. The problem in developing the development on fine-grained soil is the presence of expansive clay soil (Brotodiharjo, 1990). Where the Jatinangor region is dominated by cohesive fine-grained soils, which may contain clay minerals with great expansionary power that could affect the stability of the above ground infrastructure. The expansionary power of the expansive soil itself depends on the type and quantity of minerals, the ease of exchange of the ions or so-called cation exchange capacity and the electrolyte content and the structure of the mineralized layer (Herina, 2005).

Purpose of Paper

The underlying thing to examine the potential of land swelling in Jatinangor itself is because there are some infrastructures that fail so that endangers the users of the infrastructure. After the observation, there were several points of location in Jatinangor that suffered damage to infrastructure such as the UNPAD bridge located at the back gate which is actually new because it has not been more than 5 years old but has experienced cracks. In addition, the bridge UNPAD located next to the arboretum also experienced subsidence that the campus was forced to close access to that direction.

LITERATUR REVIEW

Mechanism of swelling soil

Expansive clay of the soil, is one type of fine-grained colloidal soil, formed from expansive minerals. Besides having general properties, it also has characteristic properties, ie expansive mineral content has a high ion exchange capacity, resulting in expansive clay having the potential for shrinkage, in case of an increase or decrease in water content. If there is an increase in water content, the expansive soil will expand along with increased pore water pressure and developmental pressures and if water content decreases, shrinkage will occur. Depreciation that occurs, if the decrease in water content exceeds the shrinkage limit.

The expansive clay expanse of the soil depends on the type and quantity of minerals, the ease of exchange of the ions or the cation exchange capacity and the electrolyte content and the structure of the mineralized layer (Herina, 2005). Clay minerals that make up the expansive clays are generally montmorillonite, illite, and kaolinite. Of the three types of minerals, montmorillonite has the greatest growth power (Grim, 1968), so its presence is thought to be a major factor determining the expansive nature of the clay type. Knowing the mineralogical content contained in the soil/rock can be used to estimate the expansive nature of clay.

The process of swelling and shrinking is largely due to capillary events or changes in water content in the soil. Soils contain much clay changes volume when water content changes. The reduction of water content followed by an increase in effective stress causes the volume of soil to shrink and otherwise the addition of moisture content causes expansion.

Geology characteristic on research area

Based on previous geological mapping results, the geology of the study area consists of three rock units (Sandio et al, 2016), namely: Pyroclastic fall breccia, pyroclastic flow breccia, and tuff unit.

1. Pyroclastic fall breccia unit

   This unit is dominated by grain supported breccias, has a light brown color, angular component shape, andesite frosted components that have a fresh gray color, dark gray color, the grain size of porphyritic, hypocristalline, packed inequigranular, subhedral crystal form, mesocratic mineral color index. Matrix in the form of fresh cream white tuff, light brown color, angle grain shape, medium sorting, closed pack, tuff fine tuff-tuff grain.

2. Pyroclastic flow breccia unit

   This unit is dominated by breccia matrix supported, has a fresh brown color, dark brown color, angular shape components, open packing, frozen andesite igneous components that have a fresh gray color, dark gray, porphyritic grains, hypocrystalline crystalline degrees, inequigranular packs, subhedral crystal forms, mesocratic mineral color index. Matrix in the form of fresh cream white tuff, light brown color, grain angle grain shape, medium sorting, sealed pack, tuff fine tuff-tuff grain.

3. Tuff unit

   This unit is dominated by tuff with fresh cream color, light brown color, fine grain size, angle grain angle shape, medium sorting, hard hardness, closed pack, glass mineral. There are quartz minerals, plagioclase, and pyroxene.

METHODOLOGY

To get swelling index value is done by laboratory testing with free swell index test method. A method of testing soil physical properties by observing the extent of soil expansion within a colloid ie distilled water (distillation) and kerosene (kerosene) within 24 hours or more. The concept used in this test is where the soil soaked in distilled water will be swelling, while soils soaked in kerosene will not develop due to their non-polar colloidal nature (Anonymous, 1977). All stages of testing using standard Indian Standart 2720 Part40 (1977).

Furthermore, with the value of swelling index at some point of soil sampling, zonation of the swelling index of land that will represent the potential of land swelling in the research area. In addition, data from swelling index values at some sampling points will be matched with XRD results to find out the type of clay minerals contained in the soil.

XRD analysis aims to determine the dominant clay mineral content in soil samples. The analysis used from this result is by looking at the aspect of the d-spacing value at the top of the major, the angle of 2θ, and the presence of the minor peak. The patterns are then matched to the XRD result list table and other additional information in Chen (1977) and analyzed based on the origin of their geometric precipitates.

RESULT AND DISCUSSION

Based on the description of soil in the field at the time of engineering geology mapping and laboratory test results related to soil physical properties, the study area is divided into three units of land according to the USCS soil classification system, namely: clay high plasticity (CH), silt high plasticity (MH), and silt low plasticity (ML).

The result of free swell index test at some point of uninterrupted soil sampling has swelling index value between 3,45% - 22,88%. So based on the classification of Indian Standart.2720 Part40 (1977) which refers to the distribution of swelling index values in the research area, it can be concluded that the research area is included in the low-moderate.

Table 1 Swelling value of differential free swell and degree of expansiveness

Sample code	Differential free swell (%)	Degree of expansiveness
NYW1	18,33	Low
NYW2	17,14	Low
NYW3	4,35	Low
NYW4	11,20	Low
NYW5	3,45	Low

NYW6	7,50	Low
NYW7	4,35	Low
NYW8	22,88	Moderate
NYW10	21,74	Moderate

Based on the X-ray diffraction pattern of the five curves in each sample, it can be seen the d-spacing value of each peak intensity value in the range 0º2θ to 20º2θ is as follows:

1. NYW1 sample has a d-spacing pattern of 7.321Å (12,079º2θ) and 4,467Å (19,857º2θ).
2. NYW2 sample has a d-spacing pattern of 7.226Å (12.237º2θ); 4,878Å (18,168º2θ); and 4,473Å (19,828º2θ).
3. NYW3 sample has a d-spacing pattern of 7.308Å (12,101º2θ) and 4,457Å (19,092º2θ).
4. NYW4 sample has a d-spacing pattern of 20.659Å (4,273º2θ); 7,304Å (12,107º2θ) and 4,456Å (19,905º2θ).
5. NYW5 sample has a d-spacing pattern of 7.331Å (12,062º2θ) and 4,460Å (19,889º2θ).
6. NYW6 sample has a d-spacing pattern of 7.275Å (12.155º2θ); 4,849Å (18,281º2θ) and 4,477Å (19,813º2θ).

Referring to Chen (1977), based on the d-spacing pattern and the 2θ angles on the whole the sample was identified as a diffraction pattern in the kaolinite mineral gap. However, in the NYW4 sample there is little difference in d-spacing pattern and 2 angles at the initial peak, which is probably caused by the impurity material in the clay mineral body. But after that, the next peak reading has followed the diffraction pattern of kaolinite minerals. According to Nelson (2004), excellent kaolinite is formed from the rich aluminosilicate-derived material produced by weathering in temperate temperatures such as in volcanic rock or in areas with hydrothermal activity. This can be explained because the location of soil sampling is present in pyroclastic flow breccia and tuff units.

Table 2 Type of clay minerals on each sample based on XRD analysis

Sample code	Geology unit (Sandio et all, 2016)	Swelling potential	Type of clay mineral
NYW1	Tuff	Low	Kaolinite
NYW2	Tuff	Low	Kaolinite
NYW3	Pyroclastic fall breccia	Low	Kaolinite
NYW4	Tuff	Low	Kaolinite
NYW5	Pyroclastic flow breccia	Low	Kaolinite
NYW6	Tuff	Low	Kaolinite

CONCLUSION

The plasticity of the soil is caused by the interaction of water ions with the clay mineralized surface, so that in the presence of high plasticity properties in the study area it indicates a lot of clay minerals. Volcanic rocks rich in silica minerals (quartz, feldspar, mica), when subjected to chemical weathering of the hydrolysis process will produce clay minerals. This is what causes the soil result of weathered many clay minerals with different types depending on the chemical content of rocks and processes that occur during the formation of clay minerals.

Based on the free swell index test results, the research area has a swelling index of the index value between 3.45% - 22.88%, which is classified into the category of low-medium to expand potential. While based on XRD test for determination of clay minerals type found in the research area, got a result in six samples spread in each zonation of the index value of land swelling which shows that six samples dominated by kaolinite clay mineral type. This is what causes the expansion rate of the research area based on swelling index value spread is relatively low.

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